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(71) Applicant *(for all designated States except US)*: **CRP GROUP LIMITED** [GB/GB]; Stanley Way, Stanley, Skelmersdale, Lancashire WN8 8EA (GB).

(72) **Inventors; and**
(75) **Inventors/Applicants** *(for US only)*: **SOMERVILLE, David, Michael, Ruthven** [GB/GB]; 93 Lincoln Drive, Aspull, Wigan WN2 1XB (GB). **LACE, David, Gordon** [GB/GB]; 293 Liverpool Road, Rufford, Lancashire L40 1SE (GB).

(74) Agent: W.P. THOMPSON & CO.; Coopers Building, Church Street, Liverpool L1 3AB (GB).

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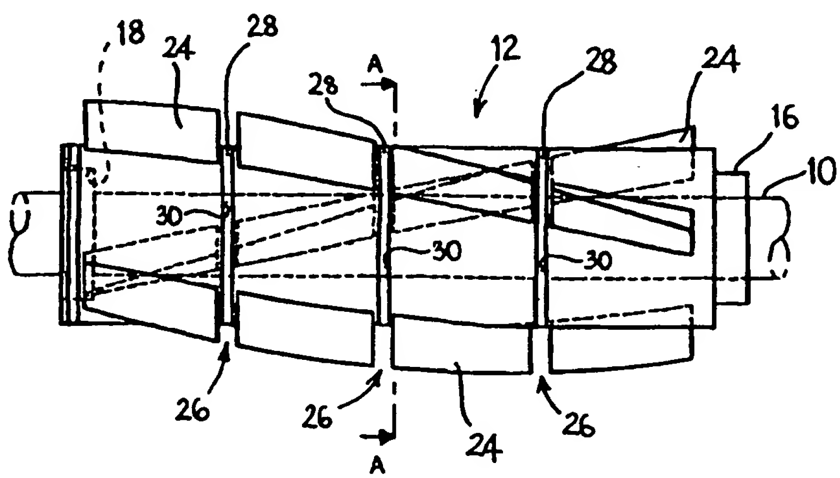
(54) Title: PROTECTION OF UNDERWATER ELONGATE MEMBERS




(57) Abstract: An underwater cladding (12) for a pipe (10) or other elongate member is formed from syntactic foam and has one or more external helical strakes (24) to interrupt or reduce vortex induced vibrations. The cladding may be formed from a series of pre-formed sections (12', 12'') which are fitted onto the elongate member (10) or may comprise a moulded cladding (12''') formed directly on the pipe.

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DESCRIPTION

PROTECTION OF UNDERWATER ELONGATE MEMBERS

The present invention relates to the protection of underwater pipes, cables or other elongate members.

When water flows past an underwater pipe, cable or other elongate member of circular cross section, vortices are shed alternately from each side. The effect of these vortices is to induce fluctuating, across-flow forces on the structure. If the natural frequency of the structure is close to the shedding frequency of the vortex the member can be caused to vibrate with a large oscillation amplitude.

Such oscillation not only causes the pipe, cable or member to bend more than is desirable, but can also induce unwanted forces on a connector (either underwater or above water) to which the pipe, cable or the like is secured. In extreme cases, the coupling between the pipe, cable or the like and the connector is damaged.

A different problem arises from the harsh underwater environment through which such pipes, cables or the like pass in use. It is known to cover the pipes, cables or other elongate members with a protective cladding during use in order to provide protection against impact and to reduce damage generally as the elongate member moves. However, in the case of an underwater pipe the fluid passing through the pipe is often at an elevated temperature, which can cause problems since the surrounding water can cool the fluid to an unacceptable degree.

It is an object of the present invention to overcome or alleviate the problems associated with the prior art.

In accordance with a first aspect of the present invention, an underwater cladding for an elongate member comprises syntactic foam and further comprises one or more external projections to interrupt or reduce vortex induced vibrations.

By forming the cladding from syntactic foam the pipe, cable or other elongate member is very well insulated and additionally the buoyancy of the clad pipe can be controlled by selection of the appropriate syntactic foam.

The interruption or reduction of the vortex induced vibrations by means of the or each external projection, the damage to the pipe, cable or the like and any fitting to which it is connected can be greatly reduced or even avoided.

In the present application, the term "syntactic foam" is intended to mean a composite material formed from microscopic, hollow lightweight fillers intimately blended with a binder, base or matrix material. The lightweight hollow filler typically comprises hollow glass microspheres (sometimes referred to as glass bubbles) which are blended with the binder, base or matrix material when the latter is in liquid form, the binder, base or matrix material then being cured with an appropriate curing compound. Typical binder, base or matrix materials comprise epoxy resins (cured with an anhydride curative) and polyurethane resin (cured with an isocyanate curative).

The cladding can be formed either from pre-formed sections and fitted onto the elongate member or, alternatively, may be moulded directly onto the elongate member.

Preferably the or each projection is substantially elongate. The or each

projection should also preferably be sharp-edged and preferably triangular in cross-section.

The height of the or each projection is preferably from 0.1 to 0.30 times (more preferably 0.1 to 0.15 times) the external diameter of the cladding.

Preferably, the or each projection is substantially helical. If so, the pitch is preferably from 3 to 20 times, and more preferably approximately 15 times (or alternatively approximately 5 times), the external diameter of the cladding.

Preferably, there are a plurality of external projections, e.g. three, and they are advantageously evenly spaced around the periphery of the cladding.

The projections may be resiliently compressible or deformable. This allows the clad pipe to be fed through conventional pipe-laying apparatus without fouling. The projections may be hollow or may be solid.

Alternatively, the projections could be substantially undeformable.

The cladding may be in the form of a series of substantially tubular or part-tubular preformed sections which, when assembled, form a longitudinal through passage which is shaped and dimensioned to receive a pipe or other elongate member to be clad.

In accordance with a second aspect of the present invention, an underwater cladding for an elongate member comprises one or more substantially helical projections to interrupt or reduce vortex induced vibrations, wherein the outer surface of the cladding is substantially circular in cross-section and the pitch of the or each projection is from 3 to 20 times the external diameter of the cladding.

Preferably, the pitch of the or each projection is from 12 to 17 times the external diameter of the cladding.

Alternatively, in another arrangement the pitch of the or each projection is from 3 to 7 times the external diameter of the cladding, more preferably approximately 5 times the external diameter of the cladding.

The height of the or each projection is preferably from 0.1 to 0.3, and more preferably 0.1 to 0.15, times the external diameter of the cladding.

The invention also includes an underwater elongate member, e.g. an underwater pipe, comprising an underwater cladding in accordance with the present invention.

By way of example only, specific embodiments of the present invention will now be described with reference to the accompanying drawings, in which:-

Fig. 1 is a side elevation of a section of pipe fitted with an embodiment of cladding in accordance with the present invention;

Fig. 2 is a cross-section of the clad pipe shown in Fig. 1, looking in the direction of arrows A-A;

Fig. 3 is an enlarged cross-section through one of the strakes of Fig. 1;

Fig. 4 is an end view of the cladding illustrated in Fig. 1;

Fig. 5 is a cross-section through a second embodiment of cladding in accordance with the present invention, through a portion corresponding to the cross-section A-A of Fig. 2;

Fig. 6 is a side elevation of a section of pipe fitted with a third embodiment

of cladding in accordance with the present invention; and

Fig. 7 is a cross-section of the clad pipe shown in Fig. 6, looking in the direction of arrows B-B in Fig. 6.

Referring firstly to Figs. 1 to 4, pipe 10 is clad in a protective ducting 12. The ducting comprises a tubular, flexible, impervious casing formed from a syntactic foam. The casing comprises a plurality of identical, releasably engageable, semi-tubular sections 12' which are arranged with respect to one another to provide a cylindrical passage 14 therethrough, which is dimensioned and shaped to receive the pipe 10. In use, longitudinally adjacent sections are secured to one another by fitting a reduced outer diameter end spigot portion 16 of one section into a complementarily-shaped enlarged inner diameter end socket portion 18 of the adjacent section.

The ducting is similar in general terms to the protective ducting described in GB-A-2260590 and, although not illustrated in the drawings of this application, diametrically-opposed sections may be "staggered" by approximately half the length of a section to ensure that the vertical joints between longitudinally adjacent sections are not aligned with the vertical joints between diametrically-opposed longitudinally adjacent sections.

Each section of the ducting is also provided with three identical, part-helical strakes 24. As illustrated in Figs. 2 and 4, the strakes are angularly spaced by 120° at any cross-section through the strakes. The strakes on each section are arranged such that when the cladding is assembled from the plurality of cladding sections, the

strakes thereby formed on the exterior of the cladding thus formed are substantially continuous, with the exception of regularly longitudinally spaced slots 26 for receipt of securing bands 28 of metal or other material which are located in the circumferential recess 30 in the assembled ducting.

As mentioned previously, the semi-tubular sections 12' are formed from a syntactic foam. In the present embodiment, the syntactic foam comprises a polyurethane resin into which glass microspheres are introduced and intimately mixed while the resin is in liquid form. The intimately-blended mixture is then reacted with an isocynate curative and is used to fill appropriately-shaped moulds, from which the preformed semi-tubular sections 12' are removed, producing a semi-tubular shell with strake portions moulded into it.

In use, the preformed sections 12' are located on the exterior of a section of pipe to be protected and are secured to each other around the pipe by means of the aforementioned spigot and socket portions 16, 18 and by means of the metal banding 28. The ducting thus formed comprises three helical, substantially continuous (with the exception of the gaps 26 provided for receipt of the securing bands) strakes 24. As best seen in Fig. 3, the strakes are substantially triangular in cross-section and are sharp-edged. It has been found that the pitch of the strakes should be from 4 to 20 times the external diameter of the cladding. Preferably the pitch of the strakes is from 14 to 18, and more preferably approximately 16, times the external diameter of the cladding and the height of the strakes should be 0.1 to 0.30 times the external diameter of the cladding. Alternatively, if the pitch of the strakes is from 3 to 7 times

the external diameter of the cladding, the heights of the strakes can be from 0.1 to 0.15 times the external diameter of the cladding. Preferably the pitch of the strakes is approximately 5 times the external diameter of the cladding. There should also preferably be, as illustrated in the first embodiment, three helical strakes, although fewer (one or two) or more strakes can be provided if desired.

When a pipe is clad in this way and is submerged under water, the presence of the strakes prevents the formation of, or significantly reduces the intensity of, vortices and thereby eliminates or reduces vortex induced vibrations. At the same time, the very effective insulation provided by the syntactic foam from which the cladding is formed increases the insulation of the pipe and of the fluid passing through it and reduces or eliminates the problems associated with loss of heat.

The second embodiment, illustrated in Fig. 5 is very similar to that of Figs. 1 to 4, the only difference being that, as illustrated in Fig. 5, the cladding 12" is formed from a tubular shell which is provided with a single, longitudinally extending slit 34 extending through the wall of the casing along the whole of its length. This enables the casing to be fitted onto a pipe by pulling apart the portions of the casing on either side of the slit and manoeuvring the casing onto the pipe. The syntactic foam forming the casing has sufficient resilience to allow this fitting procedure to take place. A plurality of casings is usually fitted, end-to-end, to cover the desired length of pipe. The construction, operation and securing of the second embodiment is otherwise identical to that of the first embodiment.

A third embodiment is illustrated in Figs. 6 and 7. The dimensions of, and

material used to form, the third embodiment are identical to that for the first two embodiments, but instead of being formed in pre-formed sections and subsequently fitted onto a pipe, the cladding 12" is moulded directly onto the pipe to be protected. Since the cladding is moulded directly onto the pipe and is secured thereto, the slots 26 and securing bands 28 used in the first two embodiments can be dispensed with.

In each of the embodiments, the helical strakes provide protection against vortex induced vibrations whilst the use of syntactic foam for the construction of the cladding provides increased thermal insulation.

The invention is not restricted to the details of the foregoing embodiments. For example, syntactic foams other than those referred to may be used if desired. Moreover, if the dimensions of the cladding and the number, shape, and relative dimensions of the strakes may be varied to suit different conditions and to provide different desired results. Also, the spigot and socket portions 16, 18 may be dispensed with if desired. Instead, longitudinally adjacent portions of the preformed sections may abut each other end-to-end.

## CLAIMS

1. An underwater cladding for an elongate member, comprising syntactic foam and further comprising one or more external projections to interrupt or reduce vortex induced vibrations.

2. An underwater cladding as claimed in claim 1, wherein the cladding comprises a plurality of pre-formed sections which are assembled onto the elongate member.

3. An underwater cladding as claimed in claim 1, wherein the cladding is moulded onto the elongate member.

4. An underwater cladding as claimed in any of the preceding claims, wherein the or each projection is elongate.

5. An underwater cladding as cladding as claimed in any of the preceding claims, wherein the or each projection is sharp-edged.

6. An underwater cladding as claimed in any of the preceding claims, wherein the or each projection is triangular in cross-section.

7. An underwater cladding as claimed in any of the preceding claims, wherein the outer surface of the cladding is substantially circular in cross-section and the height of the or each projection is from 0.1 to 0.3 times the external diameter of the cladding.

8. An underwater cladding as claimed in claim 7, wherein the height of the or each projection is from 0.1 to 0.15 times the external diameter of the cladding.

9. An underwater cladding as claimed in any of the preceding claims,

wherein the or each projection is substantially helical.

10. An underwater cladding as claimed in claim 9, wherein the outer surface of the cladding is substantially circular in cross-section and wherein the pitch of the or each projection is from 3 to 20 times the external diameter of the cladding.

11. An underwater cladding as claimed in claim 10, wherein the pitch of the or each projection is from 12 to 17 times the external diameter of the cladding.

12. An underwater cladding as claimed in claim 11, wherein the pitch of the or each projection is approximately 15 times the external diameter of the cladding.

13. An underwater cladding as claimed in any of claims 1 to 10, wherein the pitch of the or each projection is from 3 to 7 times the external diameter of the cladding.

14. An underwater cladding as claimed in claim 13, wherein the pitch of the or each projection is approximately 5 times the external diameter of the cladding.

15. An underwater cladding as claimed in any of the preceding claims, comprising a plurality of external projections.

16. An underwater cladding as claimed in claim 15, comprising three external projections.

17. An underwater cladding as claimed in claim 15 or claim 16, wherein the projections are substantially identical.

18. An underwater cladding as claimed in any of claims 15 to 17, wherein the projections are substantially evenly spaced around the periphery of the cladding.

19. An underwater cladding as claimed in any of the preceding claims,

wherein the or each projection is resiliently compressible or deformable.

20. An underwater cladding as claimed in any of claims 1 to 18, wherein the or each projection is substantially undeformable.

21. An underwater cladding for an elongate member, comprising one or more substantially helical projections to interrupt or reduce vortex induced vibrations, wherein the outer surface of the cladding is substantially circular in cross-section and the pitch of the or each projection is from 3 to 20 times the external diameter of the cladding.

22. An underwater cladding as claimed in claim 21, wherein the pitch of the or each projection is from 12 to 17 times the external diameter of the cladding.

23. An underwater cladding as claimed in claim 22, wherein the pitch of the or each projection is approximately 15 times the external diameter of the cladding.

24. An underwater cladding as claimed in claim 21, wherein the pitch of the or each projection is from 3 to 7 times the external diameter of the cladding.

25. An underwater cladding as claimed in claim 24, wherein the pitch of the or each projection is approximately 5 times the external diameter of the cladding.

26. An underwater cladding as claimed in any of claims 21 t o 25, wherein the height of the or each projection is from 0.1 to 0.3 times the external diameter of the cladding.

27. An underwater cladding as claimed in claim 26, wherein the height of the or each projection is from 0.1 to 0.15 times the external diameter of the cladding.

28. An underwater elongate member comprising an underwater cladding as

claimed in any of the preceding claims.

29. An underwater pipe comprising a cladding as claimed in any of claims 1 to 27.

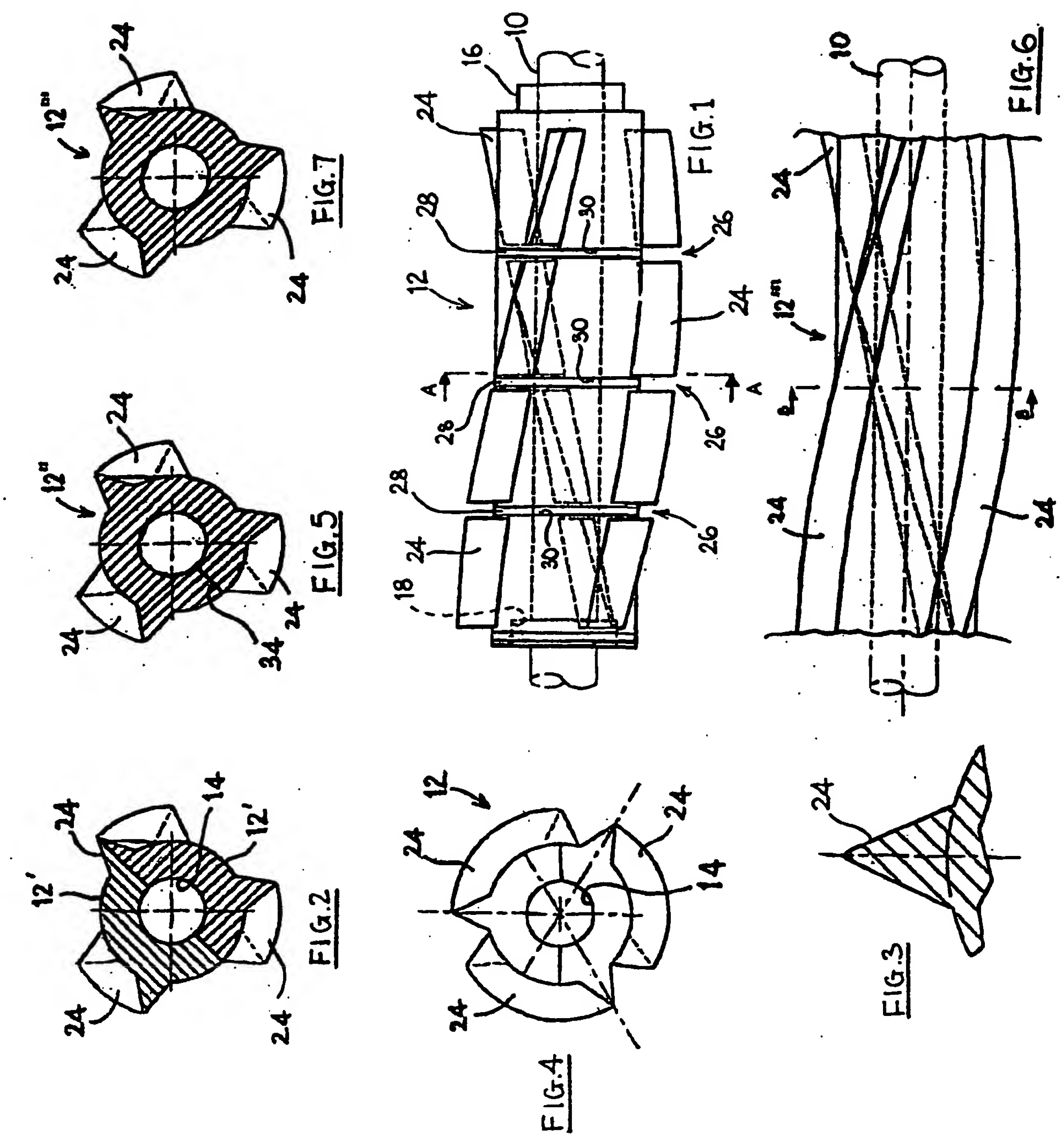

FIG.1 FIG.2 FIG.3 FIG.4 FIG.5 FIG.6 FIG.7

# INTERNATIONAL SEARCH REPORT

International Application No
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**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 7 F16L1/12 E02B17/00 F15D1/10

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16L F15D E02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2
NL – 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer
Maukonen, K

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| C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT | | |
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